ÖGH Herpetozoa
Austrian Herpetological Society

Herpetozoa 38: 311–320 (2025)
DOI 10.3897/herpetozoa.38.e162906

Tadpoles of three sympatric spiny frogs (Anura, Dicroglossidae, *Quasipaa*) from Wuyishan, China

Tianyu Qian[1], Cheng Li[1], Sining Huang[1], Bo Chen[1], Yujuan Guo[1], Jianping Jiang[1,2]

1 *Chengdu Institute of Biology, Chinese Academy of Sciences, Chengdu 610213, China*
2 *Mangkang Biodiversity and Ecological Station, Xizang Ecological Safety Monitor Network, Changdu 854500, Xizang, China*

https://zoobank.org/9F28F858-18A5-44B2-9A96-EAECE782345D

Corresponding author: Jianping Jiang (jiangjp@cib.ac.cn)

Academic editor: Günter Gollmann ♦ **Received** 26 June 2025 ♦ **Accepted** 24 September 2025 ♦ **Published** 10 October 2025

Abstract

During a rapid survey in Wuyishan, China, tadpoles of three *Quasipaa* species were collected from the same stream. Molecular data confirmed that these tadpoles belong to *Q. exilispinosa*, *Q. spinosa*, and *Q. jiulongensis*. Their external morphology was examined and described. Based on our initial observations, the tadpoles of these three species can be distinguished in the field by the following coloration patterns: *Q. jiulongensis* lacks large spots on the upper tail musculature; *Q. spinosa* exhibits a dark stripe at the body–tail junction when viewed from above; and *Q. exilispinosa* has large spots on the upper tail musculature but lacks a dark stripe at the body–tail junction. This study provides the first description of the tadpole of *Q. jiulongensis*.

Key Words

Amphibia, DNA barcoding, external morphology, frogs, larvae

Introduction

Spiny frogs of the genus *Quasipaa* Dubois, 1992, inhabit mountain streams in southern China and the Indochina Peninsula. Their tadpoles are large, bottom-dwelling, and feed opportunistically (Fei et al. 2009). Observations indicate that *Quasipaa* tadpoles are nocturnal, lying on the bottom or hiding in crevices during the day, and are often found in still water within mountain streams (Fei et al. 2009). Most *Quasipaa* tadpoles are known to overwinter, with some, such as *Q. robertingeri*, potentially overwintering for two seasons (Fei et al. 2009). The largest reported *Quasipaa* tadpole, a *Q. verrucospinosa* specimen at Gosner stage 40, measured 91 mm in total length (Fei et al. 2009). Currently, tadpoles of 7 out of 15 *Quasipaa* species have been described, leaving eight unknown to science (Inthara et al. 2009; Frost 2025).

According to Fei et al. (2009), three *Quasipaa* species have been reported from Wuyishan (Mt. Wuyi), China: *Q. exilispinosa* (little spiny frog), *Q. spinosa* (giant spiny frog), and *Q. jiulongensis* (Jiulong spiny frog). Tadpoles of *Q. exilispinosa* and *Q. spinosa* have been described previously (e.g., Liu and Hu 1975; Ye et al. 1993; Fei et al. 2009). However, due to overlapping distribution ranges with *Q. exilispinosa* and *Q. spinosa*, the tadpole of *Q. jiulongensis* has remained unidentified and undescribed.

In this study, we provide the first description of the tadpole of *Q. jiulongensis* and redescribe the tadpoles of *Q. exilispinosa* and *Q. spinosa* based on examinations of external morphology and live coloration of specimens identified through molecular phylogenetic analyses (Jiang et al. 2005; Che et al. 2009).

Materials and methods

Four tadpole specimens of spiny frogs were collected from Dazhulan (27.6975°N, 117.6486°E, ca. 950 m elev.), Guadun (=Kuatun), Wuyishan (former Chungan Hsien), and Fujian (=Fukien) Province, China, during a rapid

Copyright *Tianyu Qian et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

herpetological survey conducted on 26 July 2023. Specimens were photographed in life in a transparent acrylic box before being euthanized with buffered clove oil and then fixed with 10% formalin for storage. Tissue samples (tail fin) were preserved in 95% ethanol for molecular analysis. All specimens were deposited at the Chengdu Institute of Biology (CIB), Chinese Academy of Sciences (CAS), Chengdu, China, with voucher numbers CIB T1024–27.

Segments of the 16S ribosomal RNA gene (16S) were used for species identification. Primer pair 16Sar-L (5′-CGCCTGTTTACCAAAAACAT-3′) and 16Sbr-H (5′-CGCCTGTTTACCAAAAACAT-3′) from Palumbi et al. (1991) were used for PCR amplification. The amplification protocol followed Ji et al. (2023). Sequencing was conducted using an ABI3730 automated DNA sequencer at Chengdu Youkang Jianxing Biotechnology Co., Ltd. (Chengdu, China). The new sequences were searched on BLAST (NCBI), resulting in approximate identity as *Quasipaa exilispinosa*, *Q. spinosa*, and *Q. jiulongensis*, respectively. For further molecular analysis, we selected 26 samples representing 11 known species and an undescribed lineage of *Quasipaa* (excluding *Q. courtoisi* and *Q. fasciculispina*, for which sequences were unavailable, and the recently described *Q. binhi* and *Q. ohlerae*; see Suppl. material 1), with *Fejervarya limnocharis* as the outgroup following Pham et al. (2022). Given documented hybridization within *Quasipaa* (Ye et al. 2013; Zhang et al. 2018; Yan et al. 2021), assigning tadpoles to specific lineages is essential for accurate identification. To achieve this, we downloaded all available 16S sequences of *Q. exilispinosa* and *Q. jiulongensis* from GenBank. For *Q. spinosa*, we downloaded all available 16S sequences from east China (Fujian, Anhui, Jiangxi, and Zhejiang), which represent the population around its type locality (Wuyishan, Fujian). The vouchers, localities, and accession numbers of all sequences used in the study are listed in Suppl. material 1. Samples were aligned using the MUSCLE algorithm with default parameters (Edgar 2004) in MEGA 12 (Kumar et al. 2024). A phylogenetic tree was constructed using Bayesian inference (BI) implemented in MrBayes 3.2.7a (Ronquist et al. 2012). Two independent runs were conducted during the BI analyses with 10,000,000 generations each, and they were sampled every 1000 generations, with the first 25% of samples discarded as burn-in. We used a convergence diagnostic threshold of PSRF ≤ 1.005 (stopval = 0.005) to automatically terminate the MCMC run once convergence was achieved.

ImageJ 1.54 g software (Schneider et al. 2012) was used to measure the tadpoles from photographs of preserved specimens taken next to a ruler (Table 1). The staging follows Gosner (1960), and the terminology for external morphology follows Altig and McDiarmid (1999). Measurements follow Inthara et al. (2009), which referenced Altig and McDiarmid (1999) and Grosjean (2006): A2R, length of the second keratodont row on the upper labium; BH, maximum height of body; BL, body length; BW, maximum width of body; DG, length of the dorsal papilla gap; ED, maximum diameter of eye; KRF, keratodont row formula; LFH, maximum height of lower tail fin; MTH, maximum tail height; NND, internarial distance; NPD, nario-pupilar distance; ODW, oral disc width; PPD, interpupilar distance; RND, rostro-narial distance; SSD, distance from tip of snout to opening of spiracle; SUD, distance from tip of snout to insertion of upper tail fin; SVL, snout–vent length; TAL, tail length (distance from opening of vent to tip of tail); TTL, total length; TMH, maximum height of tail muscle; TMW, maximum width of tail muscle; UFH, maximum height of upper tail fin.

Table 1. Measurements of tadpoles of three *Quasipaa* species. "-" indicates data not available.

Species	*Q. exilispinosa*		*Q. spinosa*	*Q. jiulongensis*
Voucher	CIB T1024	CIB T1025	CIB T1026	CIB T1027
Stage	25	37	37	25
BH	6.5	8.0	9.4	4.9
BL	14.7	15.7	22.2	11.5
BW	8.8	9.1	12.6	6.5
DG	1.4	1.4	2.8	1.7
ED	1.6	1.7	2.6	1.5
LFH	2.0	-	3.2	1.5
MTH	8.2	-	11.7	6.1
NND	3.3	3.2	4.3	2.6
NPD	2.8	2.8	3.9	2.0
ODW	3.8	3.6	5.6	3.3
PPD	5.5	5.6	7.7	4.0
RND	2.3	2.3	3.1	1.8
SSD	7.6	9.2	13.8	7.3
SUD	13.7	14.9	22.2	10.4
SVL	17.7	19.3	27.3	12.8
TAL	29.4	-	45.5	20.6
TTL	46.6	-	72.6	33.2
TMH	4.7	4.8	7.9	2.5
TMW	3.8	4.4	6.7	2.4
UFH	3.2	-	4.3	2.2
A2R	2.5	2.4	4.5	2.3

Results

Tadpole identification

The reconstructed phylogeny is presented in Fig. 1. Our newly collected samples formed three distinct lineages. Specimen CIB T1027 clustered within the monophyletic *Q. jiulongensis* clade, which included sequences from the same locality as our new samples. Samples of *Q. spinosa* from its type locality clustered into multiple lineages; however, the clade containing only *Q. spinosa* samples from Zhejiang, Fujian, and Hunan provinces, with strong support (BPP = 1.00), was considered the "true" *Q. spinosa* lineage and included our tadpole sample CIB T1026. Specimens CIB T2024 and CIB T1025 clustered with 13 *Quasipaa exilispinosa* samples from the same locality (Wuyishan, Fujian Province) and one sample from Dehua, Fujian Province, with strong support (BPP = 1.00). Although some *Q. exilispinosa* samples were intermixed with *Q. spinosa* in a higher-level clade, our new samples were clearly identified as *Q. exilispinosa* based on their clustering within a distinct lineage containing only *Q. exilispinosa* samples.

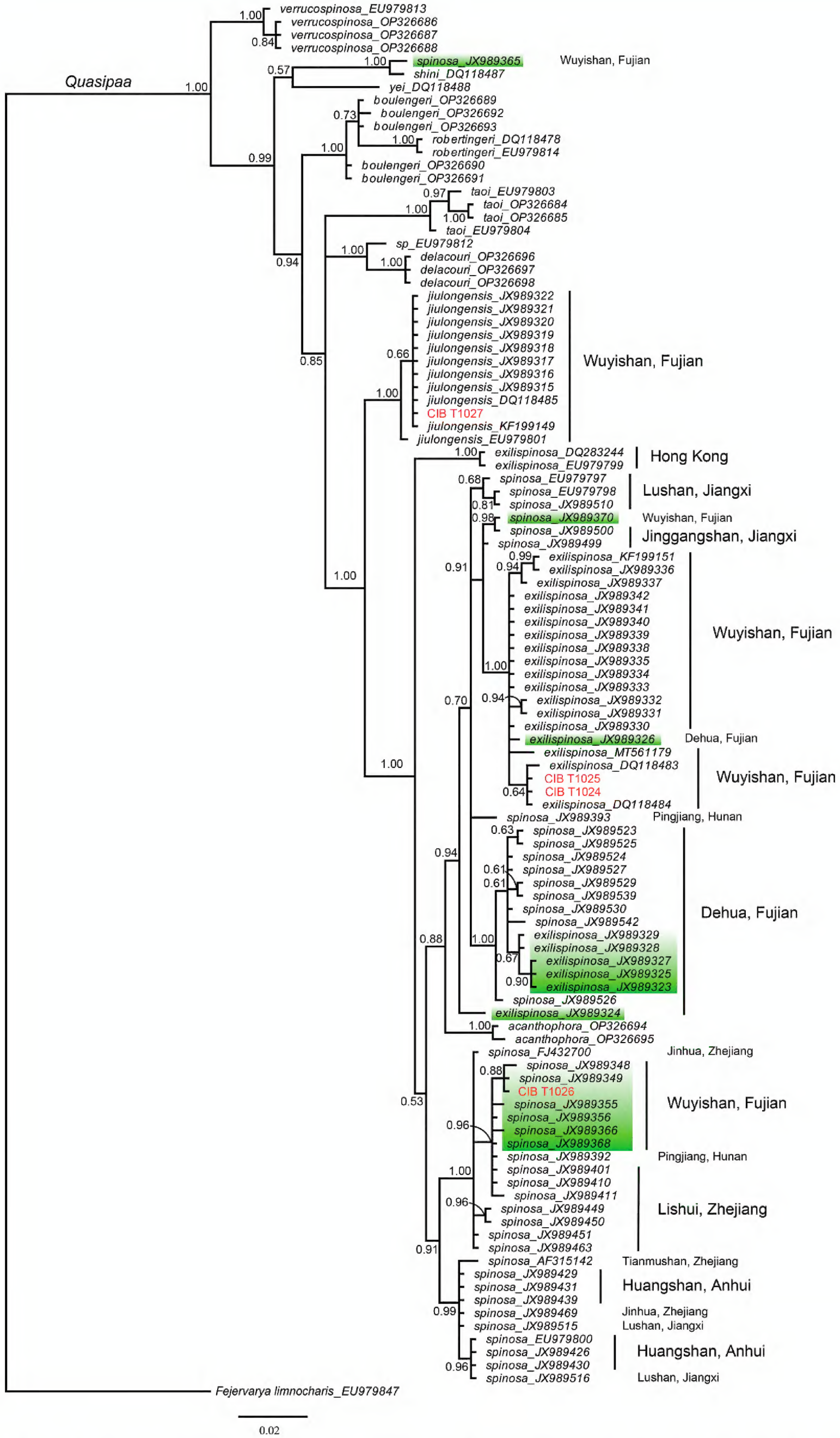

Figure 1. Reconstructed Bayesian topology of *Quasipaa* based on the 16S gene. New samples reported in this study are highlighted in red. Samples of *Q. spinosa* and *Q. exilispinosa* from their type localities are backgrounded in a green gradient. Numbers on nodes are Bayesian posterior probability (BPP) values.

Tadpole description

Quasipaa exilispinosa (Liu & Hu, 1975)

Figs 2, 5A, B, Table 1

Specimen examined. CIB T1024 (Stage 25, field voucher WT01) and CIB T1025 (Stage 37, field voucher WT08), collected on 26 July 2023 from Dazhulan, Guadun, Wuyishan, Fujian Province, China.

External morphology. Based on the specimen CIB T1024, stage 25, TTL 46.6 mm, BL 14.7 mm. In lateral view, the body is oval, and the snout is blunt; dorsally, the snout is rounded, the head is slightly wider than trunk, BW/BH 135%; the eyes are moderate in size, positioned and directed dorsolaterally, not visible from ventral view, ED/BL 11%; the pupils are round; nares positioned and directed anterolaterally, closer to snout than to eye RND/NPD 82%, NND/PPD 60%; the rim of nares not raised from the body wall; the spiracle is single, sinistral, and short; the opening of spiracle oriented posterodorsally, free from the body wall at the tip, and closer to the tip of snout than to the anal tube opening SS/BL 52%; the tail muscle is strong, gradually tapering until reaching the tail tip, TMH/BH 72%, TMH/MTH 57%; the tail fins are moderate in size, UFH/MTH 39%, LFH/MTH 24%, MTH/BH 126%; the upper fin arises at the body-tail junction, SUD/BL 93%; the lower fin is connected to the trunk; the tail tip is rounded; the anal tube is approximately conical in shape, medial, and entirely attached to lower fin, opening on lateral right side, posteriorly directed; the oral disc is positioned and directed anteroventrally, emarginated, elliptical with a median notch on the lower labium, ODW/BL 26%, ODW/BW 43%; a row of papillae on upper labium, with a large papilla gap, DG/ODW 37%; two entire rows of papillae on lower labium, the inner row is distinctly larger; KRF 1:4+4/1+1:2; the 1st–3rd tooth rows on upper labium are subequal, the inner 4th–5th rows gradually shortened; the 1st–3rd tooth rows on lower labium gradually shortened; the jaw sheaths are keratinized with fine serrations; the upper sheath is thin, covers the lower jaw, and the lower sheath is wide.

In life, the body is dark brown laterally; the tail muscle is light brown scattered with dark spots on upper edge and smaller spots on lower parts; tail fin with sparse dark pigmentation; dorsally, the body and tail are brown, and the trunk is darker; the lateral lines are goldish and clearly visible; the iris is bronze, and the pupil is black; ventrally, the body and tail is semi-translucent; the chest is pink; the abdomen is scattered with dense goldish speckles, the gut coil is clearly visible; the anal tube is covered by goldish pigments; the lower tail fin and bottom of tail muscle are scattered with sparse golden pigments; the mouth part is surrounded by goldish chromocytes.

Figure 2. Live tadpole of *Quasipaa exilispinosa* (CIB T1024, stage 25) in lateral view (**A**), dorsal view (**B**), and ventral view (**C**). Scale bar: 10 mm.

Quasipaa spinosa (David, 1875)

Figs 3, 5C, D, Table 1

Specimen examined. CIB T1026 (Stage 37, field voucher WT06) collected on 26 July 2023 from Dazhulan, Guadun, Wuyishan, Fujian Province, China.

External morphology. A large tadpole in stage 37, TTL 72.6 mm, BL 22.2 mm; the body is oval, and the snout is round, BW/BH 134%; the eyes are moderate in size, positioned and directed dorsolaterally, not visible from ventral view, ED/BL 12%; the pupils are round; nares positioned and directed anterolaterally, closer to snout than to eye, RND/NPD 79%, NND/PPD 56%; the rim of nares slightly raised from the body wall; the spiracle is single, short, square, and sinistral; the opening of spiracle oriented posterodorsally, free from the body wall at the tip, and closer to the tip of snout than to the anal tube opening, SSD/BL 62%; the tail muscle is strong, gradually tapering until reaching the tail tip, TMH/BH 84%, TMH/MTH 68%; the tail fins are moderate in size, UFH/MTH 37%, LFH/MTH 27%, MTH/BH 124%; the upper fin arises in front of the body-tail junction, SU/BL 100%; the lower fin is connected to the trunk; the tail tip is rounded; the anal tube is approximately conical in shape, medial, and entirely attached to lower fin, opening on lateral right side, posteriorly directed; the oral disc is positioned and directed anteroventrally, emarginated, and elliptical, ODW/BL 25%, ODW/BW 44%; a row of papillae on upper labium, with a large papilla gap, DG/ODW 50%; two rows of papillae on lower labium; a median notch on the lower labium, and the papillae on the inner row are distinctly larger; KRF 1:4+4/1+1:2, the 3rd tooth row on lower labium was unconnected on the left 1/3 (Fig. 5C, D); the 1st–3rd tooth rows on upper labium are subequal, the inner 4th–5th rows gradually shortened; the 1st–3rd tooth rows on lower labium are subequal; the jaw sheaths are keratinized with fine serrations; the upper sheath is thin, covers the lower sheath, and the lower sheath is wide.

In life, the body is dark brown laterally; the tail muscle is light brown scattered with pale brown spots on upper edge, and smaller and paler spots on lower parts; tail fin with sparse pale brown pigmentation; dorsally, the body and tail are brown, and the trunk is darker; a V-shaped dark stripe on body-tail junction; the lateral lines are goldish and clearly visible; the iris is bronze, and the pupil is black; ventrally, the body and tail is semi-translucent; the chest is deep purple scattered with whitish pigmentations; the abdomen is white, the gut coil is barely visible; the anal tube and hindlimbs are covered by goldish pigments; the lower tail fin and bottom of tail muscle are scattered with sparse whitish pigments; the mouth corner is surrounded by goldish chromocytes.

Remarks. The tadpoles described by Fei et al. (2009) have transparent abdomens with visible gut coils; that is not consistent with our data. However, our specimens are larger (SVL 27.3 mm vs. 18.7–22.1 mm; see Table 2), potentially indicating developed pigmentation associated with preparation for metamorphosis.

Figure 3. Live tadpole of *Quasipaa spinosa* (CIB T1026, stage 37) in lateral view (**A**), dorsal view (B), and ventral view (**C**). Scale bar: 10 mm.

Table 2. Comparative diagnosis and measurements (in mm) of *Quasipaa* tadpoles. "-" indicates data not available. Numbers in parentheses are mean values. ULPR = upper labial papillae rows; LLPR = lower labial papillae rows; N = number of specimens. For other abbreviations, see Materials and methods.

Species	Stage	*N*	TTL	SVL	KRF	Tail tip	ULPR	LLPR	Coloration	Reference
Q. exilispinosa	25	1	46.6	17.7	1:4+4/1+1:2	rounded	present	2	Body pale yellow, 3–5 dark spots dorsolaterally on tail muscle, distinct in early-stage tadpoles, sparse dots on tail fins.	This study
	37	1	-	19.3	1:4+4/1+1:2					
	28	1	-	24.5	-	bluntly pointed				Fei et al. (2009)
	42	1	49	17	-					
	30–36	7	54.1–60.9 (58.0)	18.2–20.5 (19.0)	-					
	-	153	-	-	1:3+3/1+1:2	-				Liu and Hu (1975)
	-	38	-	-	1:4+4/1+1:2					
Q. spinosa	37	1	72.6	27.3	1:4+4/1+1:2	bluntly rounded	present	2	Body blackish gray or brownish bray, middle of back light colored, 3–5 dark spots dorsolaterally on tail muscle, speckles on fins denser on lower fins (this study; Fei et al. 2009)	This study
	34–38	20	-	18.7–22.1 (20.2)	1:4+4/1+1:2 1:5+5/1+2:2 1:3+3/1+1:2					Fei et al. (2009)
Q. jiulongensis	25	1	33.2	12.8	1:4+4/1+1:2	rounded	present	2	Body pale brown, tail muscle and fins pigmented with cloud-form dark speckles, middle area of body-tail junction dark in dorsal view (this study)	This study
Q. boulengeri	-	1	55	18	1:3+3/1+1:2	bluntly pointed	present	2	Dorsum yellowish brown or light brown, tail light-colored with dark dots, a black transverse stripe between body and tail; 2–3 dark transverse bars dorsolaterally on tail muscle (Inthara et al. 2009; Fei et al. 2009)	Liu and Hu (1960)
	36–38	10	(51.9)	17.8–19.5 (18.6)	1:4+4/1+1:2; 1:3+3/1+1:2					Fei et al. (2009)
	26–28	10	40.0–49.0 (43.9)	15.3–18.1 (16.5)	-					
	31–36	10	55.1–64.0 (57.9)	18.9–21.9 (19.9)	-					
Q. shini	36–38	10	(66.3)	20.0–25.2 (23.2)	1:5+5/1+1:2; 1:4+6/1+1:1; 2:5+5/1+1:1; 1:6+5/1+1:1; 2:4+4/1+1:1	bluntly pointed	-	2	Body olive, tail light-colored, 3–4 dark spots dorsolaterally on tail muscle; a pair of white spots on 1/3 body in ventral view (Inthara et al. 2009; Fei et al. 2009)	Fei et al. (2009)
Q. robertingeri	26	-	-	-	1:3+3/1+1:2; 1:4+4/1+1:2	-	absent	2	Dorsum light brown or brownish yellow with dark dots on lateral side; tail light-yellow, a brown transverse stripe present or absent between body and tail (Fei et al. 2009)	Fei et al. (2009)
	27–35	6	-	15.5–25.0	1:4+4/1+1/2					
Q. verrucospinosa	29–40	-	-	-	-	-	-	3–4	Brown or yellowish-brown, dorsum lacks distinct pattern; tail paler with irregular blackish spots on the flanks of the muscular portion and diffuse round dark spots on the fins. The belly is colored uniformly with the body flanks. The iris is golden with four radial black streaks.	Fei et al. (2009)
	40	1	91	-	1:5+5/1+1:2					
	27–29	-	71.1–75.4	-	1:5+5/1+1:2; 2:4+4/1+1:2					
	-	-	-	-	6(2-6)/3(1)	blunt	present	3		Vassilieva et al. (2025)
Q. yei	28–29	10	39.6–47.3 (43.8)	16.1–18.7 (17.6)	-	bluntly pointed or bluntly rounded	present	2–3	Dark brown or grayish brown in early stages, body bright and yellowish green or yellowish brown in late stages; tail with or without pale gray dots posteriorly.	Fei et al. (2009)
	40	1	68.0	-	-					
	26–40	94	-	-	1:6+6/1+1:2					
	26–40	15	-	-	1:7+7/1+1:2					
	26–40	23	-	-	2:5+5/1+1:2; 1:8+8/1+1:2; 1:6+5/1+1:2					
Q. fasciculispina	28	1	71.9	30.6	2:5+5/1+1:2	slight point	present	3	Body brown with dark dots, tail creamy brown with numerous black spots.	Inthara et al. (2009)
	37	1	77.7	31.3	-					
Q. delacouri	25	6	-	10.3–14.8	3:5+5/1+1:2	-	present	2	Light greyish-yellow, the upper part of the back is darker than the ventral surface.	Thoai et al. 201 9

Quasipaa jiulongensis (Huang & Liu, 1985)

Figs 4, 5E, F, Table 1

Specimen examined. CIB T1027 (Stage 25, field voucher WT07) collected on 26 July 2023 from Dazhulan, Guadun, Wuyishan, Fujian Province, China.

External morphology. A tadpole in stage 25, TTL 33.2 mm, BL 11.5 mm; the body is oval, BW/BH 133%; the snout is slightly pointed in lateral view; the eyes are moderate in size, positioned and directed dorsolaterally, not visible from ventral view, ED/BL 13%; the pupils are round; the nares positioned and directed anterolaterally,

Figure 4. Live tadpole of *Quasipaa jiulongensis* (CIB T1027, stage 25) in lateral view (**A**), dorsal view (**B**), and ventral view (**C**). Scale bar: 10 mm.

closer to snout than to eye, RND/NPD 90%, NND/PPD 65%; the rim of nares slightly raised from the body wall; the spiracle is single, short, and sinistral; the opening of spiracle is narrower than the tube, oriented posterodorsally, free from the body wall at the tip, and closer to the tip of snout than to the anal tube opening, SSD/BL 63%; the tail muscle is relatively weak, gradually tapering until reaching the tail tip, TMH/BH 51%, TMH/MTH 41%; the tail fins are moderate in size, UFH/MTH 36%, LFH/MTH 25%, MTH/BH 124%; the upper fin arises in front of the body-tail junction, SUD/BL 90%; the lower fin is connected to the trunk; the tail tip is rounded; the anal tube is medial, entirely attached to lower fin, opening on lateral right side, and posteriorly directed; the oral disc is positioned and directed anteroventrally, emarginated, and elliptical, ODW/BL 29%, ODW/BW 51%; a row of papillae on of upper labium, with a large papilla gap, DG/ODW 52%; two rows of papillae on lower labium; a median notch on the lower labium, and the papillae on the inner row are slightly larger; KRF 1:4+4/1+1:2; the 1st–3rd tooth rows on upper labium are subequal, the inner 4th–5th rows gradually shortened; the 1st–3rd tooth rows on lower labium gradually shortened; the jaw sheaths are keratinized with fine serrations; the upper sheath covers the lower sheath; both sheaths are subequal in width.

In life, the body is pale brown laterally, scattered with goldish speckles; the tail muscle and fin are pigmented with cloud-form dark speckles, and interspersed with goldish chromocytes; dorsally, the body and tail are brown, the trunk is darker, especially the middle area of body-tail junction; the lateral lines are goldish and clearly visible; the iris is bronze, and the pupil is black; ventrally, the body and tail translucent scattered with whitish speckles along the periphery; the chest is pink; the gut coil is distinctly visible.

Discussion

Previous descriptions of *Quasipaa* tadpoles have primarily relied on line drawings (e.g., Fei et al. 2005, 2009; Inthara et al. 2009), which often lack color and pigmentation details critical for field identification (Haas et al. 2022; Qian et al. 2023). In this study, we documented the live coloration of tadpoles of three *Quasipaa* species, following Vassilieva et al. (2025). Coloration patterns on the tail and tail fin typically increase in prominence during tadpole ontogeny (Grosjean 2006). However, Fei et al. (2009) described "3–5 dark spots dorsolaterally on tail muscle" in *Q. exilispinosa* as "especially distinct in early-stage tadpoles," based on examination of seven tadpoles at stages 30–36. This trait facilitates in situ tadpole monitoring. Although we observed the absence of large spots on the upper tail musculature in a *Q. jiulongensis* tadpole at stage 25, given the limitation of the small sample size, there may exist various color patterns that were not observed and should be the focus of further investigations.

Comparative diagnostic features among known *Quasipaa* tadpoles are summarized in Table 2. The tadpole

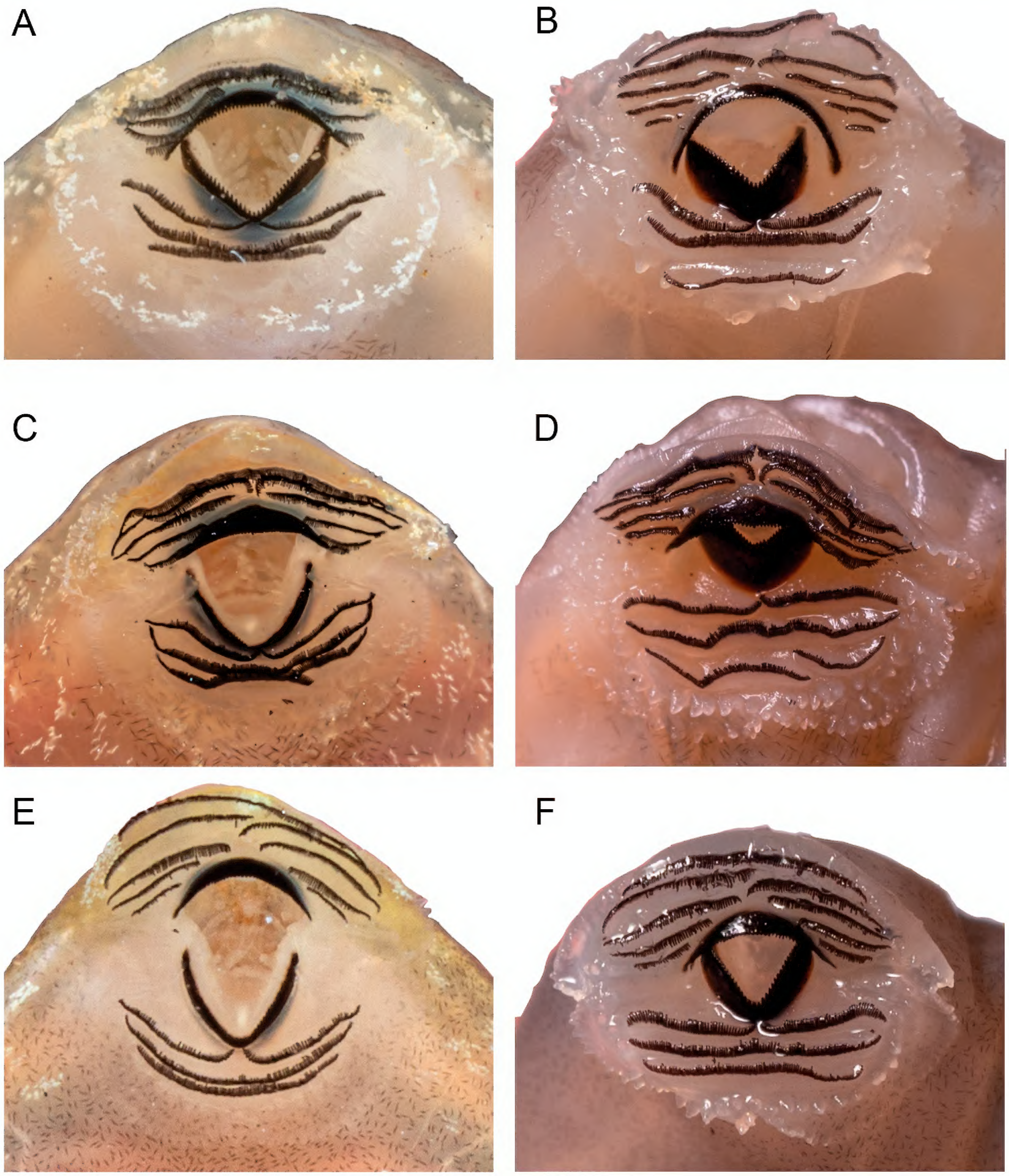

Figure 5. Oral disks of *Quasipaa exilispinosa* specimen CIB T1024 (**A, B.** In life and in preservative, respectively), *Q. spinosa* specimen CIB T1026 (**C, D**), and *Q. jiulongensis* specimen CIB T1027 (**E, F**). Images are not to scale.

of *Q. jiulongensis*, described here for the first time, exhibits a KRF that overlaps with those of *Q. exilispinosa* and *Q. spinosa* from this study, as well as *Q. boulengeri* and *Q. robertingeri* reported by other authors (Table 2). However, the papillae on the lower labium differ: the inner row is approximately twice as long as the outer row in *Q. exilispinosa* (stage 25, n = 1) and *Q. spinosa* (stage 37, n = 1) but only slightly longer in *Q. jiulongensis* (stage 25, n = 1). Three *Quasipaa* species occur in sympatry in Wuyishan, with their tadpoles co-occurring in the same stream. This study provides initial observations of differences among these sympatric *Quasipaa* tadpoles. Further studies on internal morphology could provide additional diagnostic characters (Inthara et al. 2009; Chuaynkern et al. 2018; Thoai et al. 2019; Vassilieva et al. 2025).

Additionally, given the complex phylogenetic relationships within *Q. spinosa*, analyzing samples from hybrid populations is essential to avoid misidentification.

Acknowledgments

We thank Feirong Ji for assistance with molecular experiments and Shuo Qi for expertise in phylogenetic analysis. Comments from two anonymous reviewers improved this manuscript. This work was supported by the National Natural Science Foundation of China (No. 32370482), the National Key Research and Development Program of China (2022YFF1301401), and the China Biodiversity Observation Networks (Sino BON – Amphibian and Reptile).

References

Altig R, McDiarmid RW (1999) Body plan. Development and morphology. In: McDiarmid RW, Altig R (Eds) Tadpoles. The Biology of Anuran Larvae. The University of Chicago Press, Chicago and London, 24–51.

Che J, Hu JS, Zhou WW, Murphy RW, Papenfuss TJ, Chen MY, Rao DQ, Li PP, Zhang YP (2009) Phylogeny of the Asian spiny frog tribe Paini (family Dicroglossidae) sensu Dubois. Molecular Phylogenetics and Evolution 50(1): 59–73.

Chuaynkern C, Kaewtongkum N, Ohler A, Duengkae P, Duangjai S, Makchai S, Chuaynkern Y (2018) First description of the *Nanorana* (*Chaparana*) *aenea* (Smith, 1922) tadpole from northern Thailand and additional information on the *Quasipaa* (*Eripaa*) *fasciculispina* (Inger, 1970) tadpole buccopharyngeal anatomy. Alytes 36(1–4): 93–108.

David A (1875) Journal de Mon Troisième Voyage d'Exploration dans l'Empire Chinoise. Vol. 2. Hachette, Paris, 381 pp. https://doi.org/10.5962/bhl.title.118647

Dubois (1992). Notes sur la classification des Ranidae (Amphibiens anoures). Bulletin Mensuel de la Société Linnéenne de Lyon 61: 305–352. https://doi.org/10.3406/linly.1992.11011

Edgar RC (2004) MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32(5): 1792–1797. https://doi.org/10.1093/nar/gkh340

Fei L, Ye CY, Jiang JP, Xie F, Huang YZ (2005) An Illustrated Key to Chinese Amphibians. Sichuan Publishing House of Science and Technology, Chengdu.

Fei L, Hu SQ, Ye CY, Huang YZ (2009) Fauna Sinica. Amphibia. Vol. 3. Anura. Ranidae. Science Press, Beijing, 959–1847.

Frost DR (2025) Amphibian Species of the World: an Online Reference. Version 6.2. Electronic Database. American Museum of Natural History, New York. https://amphibiansoftheworld.amnh.org/index.php [accessed: 31 May 2025]

Gosner KL (1960) A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16(3): 183–190.

Grosjean S (2006) The choice of external morphological characters and developmental stages for tadpole-based anuran taxonomy: a case study in *Rana* (*Sylvirana*) *nigrovittata* (Blyth, 1855) (Amphibia, Anura, Ranidae). Contributions to Zoology 74(1/2): 61–76. https://doi.org/10.1163/18759866-0740102005

Haas A, Das I, Hertwig ST, Bublies P, Schulz-Schaeffer R (2022) A Guide to the Tadpoles of Borneo. Tradition, Hamburg, 506 pp.

Huang, ZY, Liu BH (1985) A new species of the genus *Rana* from Zhejiang, China. Journal of Fudan University. Natural Science 24: 235–237.

Inthara C, Chuaynkern Y, Duengkae P, Grosjean S (2009) The tadpole of *Quasipaa fasciculispina* (Inger, 1970) from southeastern Thailand, with the description of its buccal anatomy. Alytes 26(1–4): 86–96.

Ji FR, Shi SC, Ma S, Shen C, Chang LM, Jiang JP. (2023) A new species of the genus *Nanorana* Günther, 1896 (Anura: Dicroglossidae) from Hengduan Mountains of China. Asian Herpetological Research 14(4): 300–318. https://doi.org/10.3724/ahr.2095-0357.2023.0025

Jiang JP, Dubois A, Ohler A, Tillier A, Chen XH, Xie F, Stöck M. (2005) Phylogenetic relationships of the tribe Paini (Amphibia, Anura, Ranidae) based on partial sequences of mitochondrial 12S and 16S rRNA genes. Zoological Science 22(3): 353–362. https://doi.org/10.2108/zsj.22.353

Kumar S, Stecher G, Suleski M, Sanderford M, Sharma S, Tamura K (2024) MEGA12: Molecular Evolutionary Genetics Analysis version 12 for adaptive and green computing. Molecular Biology and Evolution 41: 1–9. https://doi.org/10.1093/molbev/msae263

Liu CC, Hu SQ (1975) Report of three new species of Amphibia from Fujian Province. Acta Zoologica Sinica 21(3): 265–271 [pl. 1].

Palumbi S, Martin A, Romano S, McMillan W, Stice L, Grabowski G (1991) The Simple Fool's Guide to PCR, Version 2.0, Privately Published Document Compiled by S. Palumbi. Dept. Zoology, Univ. Hawaii, Honolulu, 24 pp.

Pham CT, Hoang CV, Phan TQ, Nguyen TQ, Ziegler T (2022) Hidden in the jungle of Vietnam: a new species of *Quasipaa* (Amphibia, Anura, Dicroglossidae) from Ngoc Linh Mountain. ZooKeys 1124: 23–42. https://doi.org/10.3897/zookeys.1124.89282

Qian TY, Li YH, Chen J, Li PP, Yang DD (2023) Tadpoles of four sympatric megophryinid frogs (Anura, Megophryidae, Megophryinae) from Mangshan in southern China. ZooKeys 1139: 1–32. https://doi.org/10.3897/zookeys.1139.81641

Ronquist F, Teslenko M, Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. Systematic Biology 61: 539–542. https://doi.org/10.1093/sysbio/sys029

Schneider CA, Rasband WS, Eliceiri KW (2012) NIH Image to ImageJ: 25 years of image analysis. Nature Methods 9(7): 671–675. https://doi.org/10.1038/nmeth.2089

Thoai DV, Trung CT, Thao NT, Binh NV (2019) Morphological characteristics of *Quasipaa delacouri* tadpoles in Pu Mat National Park, Nghe An province. Hue University Journal of Science: Natural Science 128(1C): 25–33. https://doi.org/10.26459/hueuni-jns.v128i1C.5330

Vassilieva AB, Nguyen TD, Sorokin PA (2025) Morphological diversity of tadpoles of fork-tongued frogs (Anura: Dicroglossidae) with different trophic specializations. Vertebrate Zoology 75: 31–57. https://doi.org/10.3897/vz.75.e139103

Yan F, Nneji LM, Jin JQ, Yuan ZY, Chen JM, Mi X, Chen HM, Murphy RW, Che J (2021) Multi-locus genetic analyses of *Quasipaa* from

throughout its distribution. Molecular Phylogenetics and Evolution 163: 107218. https://doi.org/10.1016/j.ympev.2021.107218

Ye CY, Fei L, Hu SQ (1993) Rare and Economic Amphibians of China. Chengdu, Sichuan Publishing House of Science and Technology, 1–412.

Ye SP, Huang H, Zheng RQ, Zhang JY, Yang G, Xu SX (2013) Phylogeographic analyses strongly suggest cryptic speciation in the giant spiny frog (Dicroglossidae: *Paa spinosa*) and interspecies hybridization in *Paa*. PLoS ONE 8(7): e70403. https://doi.org/10.1371/journal.pone.0070403

Zhang JY, Zhang LP, Yu DN, Storey KB, Zheng RQ (2018) Complete mitochondrial genomes of *Nanorana taihangnica* and *N. yunnanensis* (Anura: Dicroglossidae) with novel gene arrangements and phylogenetic relationship of Dicroglossidae. BMC Evolutionary Biology 18(1): e26. https://doi.org/10.1186/s12862-018-1140-2

Supplementary material 1

Vouchers, localities, and accession numbers of all sequences used in the study

Authors: Tianyu Qian, Cheng Li, Sining Huang, Bo Chen, Yujuan Guo, Jianping Jiang

Data type: xlsx

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/herpetozoa.38.e162906.suppl1